to about 27% and 24% for computer to computer and phone to phone connections respectively. Requiring an IPOP (either an IAP or IXC) to pay a local access fee to the LEC in response to Internet telephony will lead to the following two consequences:

1) Fixed, local costs will become a major portion of the total costs seen by the IAP, hindering their ability to remain competitive by lowering their own costs.

2) Free from paying this subsidy, LECs would possess a considerable advantage over IAPs and IXCs in providing Internet access.

Based on these arguments, we draw the following conclusion:

- **Regulation of IAPs will decrease competitiveness in the market for providing Internet Access.**

Policy Recommendations

We have concluded that, although Internet telephony is not currently a threat to PSTN long distance carriers, it has the potential to compete directly with those carriers at some point in the near future. Further, we have concluded that regulation of IAPs will have the adverse effect of decreasing competition in the Internet access market. Based on these conclusions, we make the following recommendations:

1) **Refrain from regulating Internet telephony at this time for the purpose of allowing the technology to mature to a level where it may compete effectively with current PSTN long distance services.**

2) **Revisit the issue at a suitable time in the future, taking into account how technological advances have improved the quality and availability of Internet telephony service and the corresponding impact on markets of long distance carriers such as the ACTA members.**

3) **Future regulation, if deemed necessary, should be structured in such a way as to not provide LECs with a competitive advantage in the market for providing Internet access.**

Seminar Representatives:

Respectfully submitted,

Andrew Sears
305 Memorial Dr. Apt. 315B
Cambridge, MA 02139
(617) 225-9738

Don O'Sullivan
84 Charles St. Apt. 4
Boston, MA 02114
(617) 557-4987

Additional Seminar Participants:

Rob Cheng
550 Memorial Dr. Apt. 23D2
Cambridge, MA 02139
(617) 225-1222

Hector J. Gallegos
305 Memorial Dr. Apt. 403A
Cambridge, MA 02139
(617) 225-9754

Paulo Goncalves
305 Memorial Dr. Apt. 418A
Cambridge, MA 02139
(617) 225-6770

Bruce Haimowitz
21 Summit Av.
Brookline, MA 02146
(617) 731-3594

Atsushi Karimata
65 East Indian Row, #31H
Boston, MA 02110
(617) 720-2066

Benoit Lecinq
143 Albany St. Apt. 321A
Cambridge, MA 02139
(617) 225-6252

Phil Mutooni
550 Memorial Dr. Apt. 16A2
Cambridge, MA 02139
(617) 225-1386

Kristin Short
305 Memorial Dr. Apt. 415B
Cambridge, MA 02139
(617) 225-9788

Thomas Weber
550 Memorial Dr. Apt. 6A2
Cambridge, MA 02139
(617) 225-1146

Greg Yashko
67 Pearl St. Apt. 3
Somerville, MA 02145
(617) 666-3088

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Appendix A: Acronym Glossary (AG)

ACTA - America's Carriers Telecommunications Association. Group of all smaller Inter-Exchange Carriers (Ma & Pop long distance companies etc.).

API - Application Programmer Interface - High level programming language specific to the Internet. i.e. Winsock.
ITAPI - Internet Telephony Application Programmer Interface.
ITVAPI - Internet Television Application Programmer Interface

ATM - Antisynchronous Transfer Mode - Packet switching network.

CO - Central Office.

ESP - Enhanced Service Provider.

FCC - Federal Communication Commission.

FTP - File Transfer Protocol.

IAP - Internet Access Provider.

IDT - International Discount Communications.

IP - Internet Protocol - Address.

IPOP - Internet Point of Presence.

ISP - Internet Service Provider - Includes: UUNET, PSINET, MCI, Sprint.

IT - Internet Telephony.

IXC - Inter-Exchange Carriers - Includes both the big long distance carriers (AT&T, MCI,
Sprint) and the smaller companies in the ACTA.

LD - Long Distance. - Usually referring to long distance carriers (Big ones: AT&T, MCI, and Sprint).

LEC - Local Exchange Carrier.

NAP - Network Access Point - Any one of five main connections forming the internet backbone.

NRC - Non-Reoccurring Charge.

ODN - Open Data Network.

OPP - Optional Payment Plan.

PBX - Private Branch Exchange - Internet phone network.

PCS - Personal Communication Service - Specific to mobile communications. i.e. mobile phones, pagers, Newton.

POP - Point of Presence - Generic term for telecommunication hardware.

POTS - Plain Old Telephone Service.

QoS - Quality of Service.

RBOC - Regional Bell Operating Companies - The seven regional carriers formed after the regulated break-up of AT&T.

RSVP - Reservation Protocol.

TCP - Transmission Control Protocol.

UDP - User Datagram Protocol - Bare minimum transfer protocol; no flow control, etc.

Appendix B: Internet Telephony Technical Background

Introduction to Internet Telephony

Internet telephony (IT) applications allow voice communication over the Internet. The sender speaks into a microphone attached to a personal computer (PC) through the PC's sound card (alternatively, the user can speak through a standard telephone connected to the PC through a special computer telephony card). The IT software then compresses the voice signal (which has been digitized by the sound card), and packages the data into packets that can be sent over the Internet (currently using the UDP protocol - see below). These packets are then sent through the user's modem to a local Internet Access Provider (IAP) which routes the packets onto the Internet. At the receiving end, the procedure is the same: packets arrive at an IAP, to whom the receiver must be connected. The packets are then sent through modems to the receiver's PC. The software on the receiver's PC then converts the data back into audio and routes it through the sound card to a speaker. Figure B1 gives a basic illustration of this architecture.

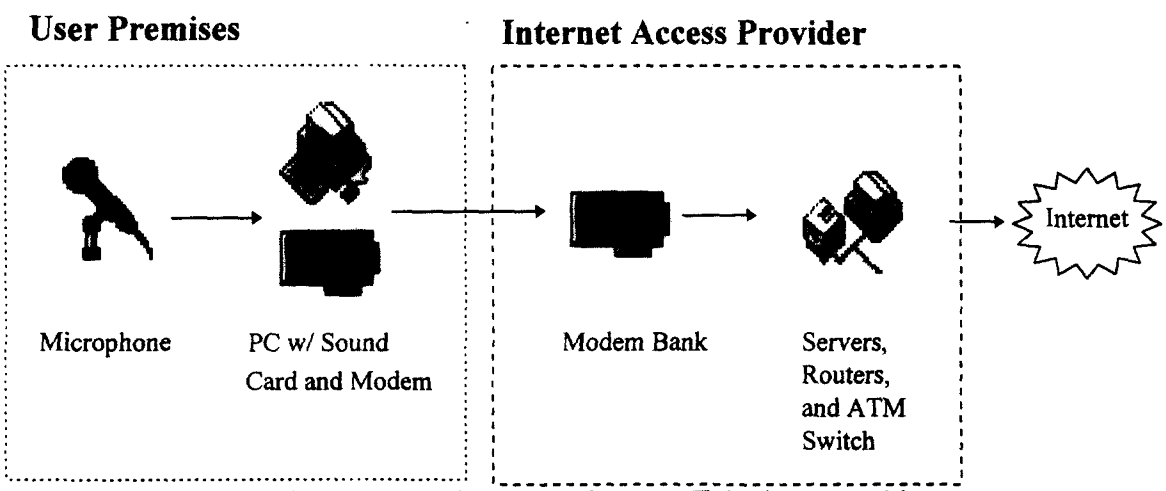

Figure B1: Current Computer-to-Computer Internet Telephony Architecture

This architecture has some major limitations. First of all, it requires both parties to have a PC with a full duplex (two-way) sound card, microphone & speakers, and a modem (14.4 Kbps or faster). In addition, the person receiving the call must be connected to the IAP and have the IT application running at the time of the call. This requires either a prior arrangement between the parties, or that the receiver remain constantly connected (which may not be feasible if the IAP has usage charges or limits).

A different architecture allows users to make IT phone calls without the need for a computer. PC's with the necessary hardware and software (or specialized "gateways" which serve the same purpose) are located at a local IT provider's premises. The user calls up the provider and is connected to one of these IT gateways. The gateway digitizes and compresses the analog voice signal, formats the data into Internet packets and routes them to the Internet. The IT provider's facility either has the necessary hardware to directly connect to the Internet, or it may connect to the Internet through a separate IAP. On the receiving end, the packets arrive at another gateway in the destination city, which converts the data back into voice and sends it through the standard Public Switched Telephony Network (PSTN) to the receiver's phone. Of course, calls can only be made to cities in which the IT provider has installed gateways. The calling process is relatively transparent to the user, requiring no more effort than making a calling card call. Figure B2 illustrates this alternative architecture (here the IT provider also serves as its own IAP).

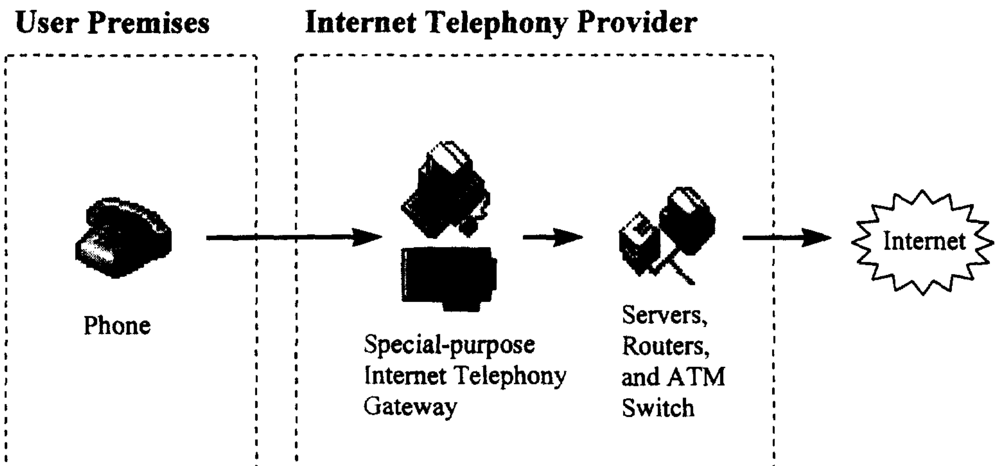

Figure B2: Alternative Phone-to-Phone Internet Telephony Architecture

Advantages of Internet Telephony

The most often cited advantage of IT over the current PSTN lies in its more efficient use of bandwidth. This efficiency is due in part to the compression of the digitized voice (which is also possible, though not necessarily common, in PSTN switches), but mostly is due to statistical sharing of network bandwidth that is made possible by packet switching. A circuit switched PSTN phone call reserves 64 Kbps of bandwidth for the entire duration of the call regardless of how much is being used (e.g. even when no one is talking, the line is still "tied-up" for the duration of the call). In contrast, packet switching allows bandwidth to be shared by multiple users or applications, resulting in higher usage of available bandwidth.

Limitations of Internet Telephony

While reserving a fixed amount of bandwidth in a PSTN call can be wasteful, it does serve as an easy way to guarantee a certain level of quality for the call. Unfortunately, the Internet is currently based on a "best effort" model of service, in which packets can be dropped (with the expectation that they will be re-sent) if the traffic in a part of the network is too high. While this model may work well enough for non-real-time applications such as e-mail, it can result in an unacceptably poor level of quality for real-time applications such as telephony. In addition, IT applications currently utilize UDP ("user datagram protocol") to send their packets. While the more common "transmission control protocol" (TCP) allows an application to scale back its transmissions when it detects increased traffic, UDP lacks this negotiated flow control. This means that IT applications may flood the Internet with UDP packets, to the detriment of other Internet traffic. Newer protocols such as RSVP ("reservation protocol") attempt to address both of these problems by providing support for real-time applications as well as management of network resources. However, these protocols are still under development and are not yet ready for widespread deployment.

In addition, the limitations of the current IT architecture mentioned earlier (need for a computer with peripherals at both ends, pre-arranged calling times) will continue to be a problem for some time. While IT gateways are under development, they do not yet have sufficient capacity to make providing IT service to the general public feasible.

Appendix C: Local Loop Cost Model

DESCRIPTION

The local loop is assumed to consist of three local distribution lines, one interoffice line, and also accounts for multiplexing at the central office (CO) between the residence and the Internet Access Provider (IAP). The local loop does not account for the lines or hookup costs between residences and the central office. Rather, it is assumed that each residence already has a phone line installed and this cost is left out of the loop. The initial line from the central office (initiated at the residence) to the IAP is considered to be of full phone capacity for each user line. In other words, while someone is using a channel on this line they are using 64 kbps. This initial line will be referred to as the *incoming line* from this point forward and it consists of multiplexing at the CO and one set of distribution lines from the CO to the IAP (containing information directly from the residence). The line from the IAP to the Internet Service Provider (ISP) will be referred to as the *outgoing line* and consists of two local distribution set of lines and one set of interoffice lines. A channel on the outgoing line will require less than 64 kbps due to compression at the IAP. The amount of compression will be based on an assumption. A list of the assumptions for the local loop can be found in a later section of this discussion. Below is a schematic which provides a visual description of the local loop as it relates to other nodes in the system.

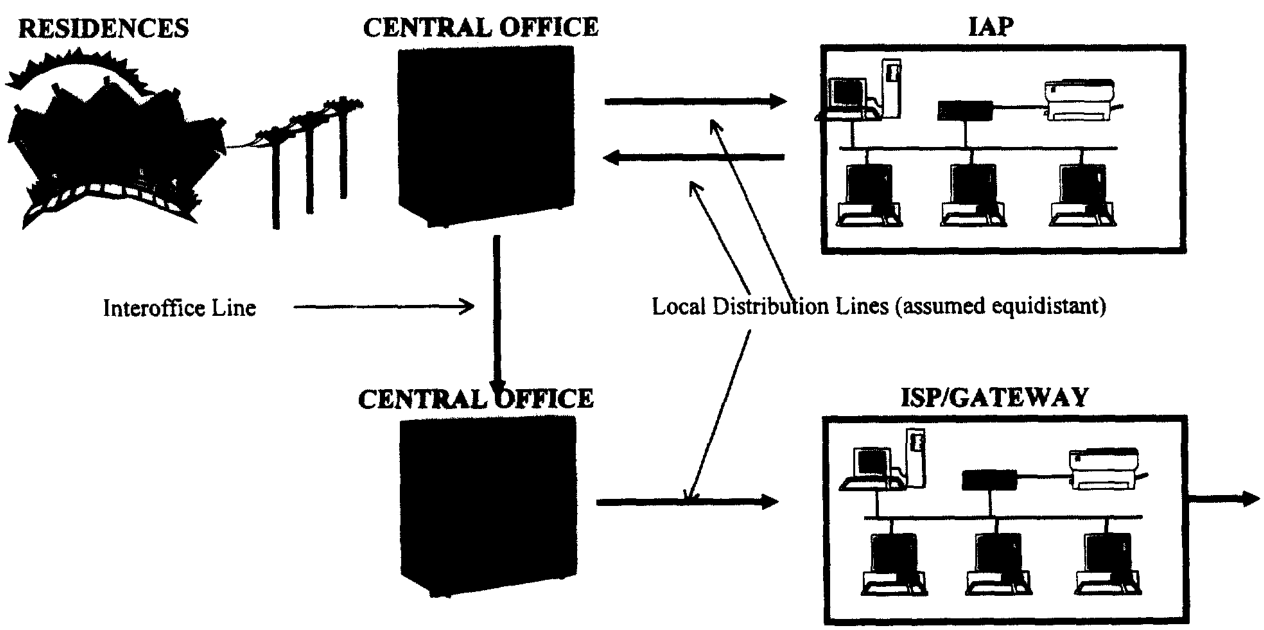

Figure C1: Local Loop Architecture

There are several input and output variables associated with the local loop, and in general these variables are common to the other two models. The six most important input variables for the local loop are: # of incoming 64 kbps lines (an aggregate of the number of subscribers), distance of the local distribution lines (from the CO to the ISP or IAP), distance of the outgoing line (from the IAP to the ISP), compression ratio at the IAP, line lease period, and the T1 - T3 threshold (which approximates a linear relation of costs between T1 and T3 lines). The output of the model can be summarized by the cost per minute per subscriber, but other aggregates are also included.

It should be noted that the local line model addresses both costs and prices. The data gathered for actual costs is from a marginal cost study performed in 1993 and was provided by the Massachusetts Department of Public Utilities. The data for the prices are those actually used by the Local Exchange Carrier NYNEX and the information was also provided through the Massachusetts Department of Public Utilities.

PURPOSE

The purpose of the local loop model is several fold. First, it allows one to determine what percentage of the total costs for Internet Telephony is related to local line costs. It also demonstrates some of the discrepancies between costs and prices and where the discrepancies are significant. Comparison of cost and price can be found in the sensitivity analysis. The local model also provides an understanding of what variables strongly affect price and cost and which do not. Lastly, the model provides a basic understanding of the local architecture necessary for Internet access.

ASSUMPTIONS

As in any model of a real world system, many assumptions were required to allow for a numerical analysis. As such, the numbers from this model should not be thought of as exact representations of actual costs and prices. Rather, one should use the numbers to attain a qualitative understanding of how local line costs relate to the bigger picture of providing Internet access, and how costs and prices are generally related to various variables.

List of assumptions:

- The type of lines are assumed to be T1 or T3.
- All numbers used to calculate costs and prices are based on information for T1 lines. T3 lines are assumed to be linearly related to the costs of T1 lines, determined by the T1 - T3 threshold.
- The number of incoming lines is an aggregate of the total number of subscribers and is considered equal to the maximum allowable number of simultaneous users.
- Twenty four simultaneous users can be contained on one incoming T1 line.
- The number of outgoing lines is an aggregate of the number of incoming lines and is related by the compression ratio at the IAP. In general, the # of incoming lines > # of outgoing lines.

- The local line costs only accounts for multiplexing at the CO between the residence and the IAP. Multiplexing at the IAP and ISP is considered to lie within the models for the gateway and the upstream.
- The three local distribution line distances are equal.
- The interoffice line distance is equal to the distance from the IAP to the ISP.
- Special services and features are not included.
- T1 and T3 lines must be leased in full, i.e. the number of incoming and outgoing lines are always integers.
- The data used in this model is directly applicable only to Massachusetts, but the qualitative results are applicable throughout the U.S.

DISCUSSION OF RESULTS

The costs and prices of the local line loop fall within a range, depending on the choice of variables. For a final numerical value one should refer to the summed price model, keeping in mind that this is not a hard number but one that falls within a broader range. The range of prices for the local loop can be loosely stated as $0.05 to $0.20 per simultaneous user per hour. As stated earlier, these are not exact numbers, but they provide a feel for the range of values that apply and fall within a range which can be considered reasonable. The local line costs, related on a per line basis, also fall within a range dependent on the input variables, approximately from $200 to $1000 per incoming T1 line and $500 to $1500 per outgoing T1 line. As these numbers are highly dependent on external factors it would be inaccurate to point to a single number for the costs. As a general rule, the values calculated stand to reason. A further feel for the results can be deduced from the sensitivity analysis, which should be referred to for a more complete understanding of the effects of various variables.

In comparing costs and prices it becomes evident that under certain circumstances costs can greatly exceed the actual charged rate. Thus the need for a subsidy becomes evident, at least in these circumstances. Although, in many cases the charged price is greater than the actual cost. The model seems to indicate that a subsidy becomes necessary when the distances between locations becomes great. This stands to reason since one of the difficulties of providing universal access is the barrier of distance. Unfortunately, since this model does not account for the local system as a whole it is inaccurate to draw conclusions concerning price versus cost except to say that for Internet telephony they are on average within the same order of magnitude and often significantly similar. Once again, one should refer to the sensitivity analysis for a clearer understanding.

SENSITIVITY ANALYSIS

The following sensitivity analysis provides an understanding of how each of the input variables affects the cost and price of the local line loop. It also can be interpreted as a further discussion of the results of the model. It should be noted that the costs and prices in the following graphs are related in terms of dollars per subscriber per hour (assuming 15 hours of use per month and 13 subscribers per 64 kbps incoming line). These numbers are merely aggregates of the costs and prices associated with a constantly used line. They are given in the above manner to help the reader form a relation to the numerics, but since they are based on assumptions their exact values become less important than the trend which is represented by the graphs themselves. The shapes and normalized values in the graphs are constant regardless of the manner used to relate the cost and price, and as such attention should be focused on the relative values rather than the numbers.

Each of the following headings describes the variable that is altered within the section below it. For the sake of consistency the variables not altered were kept at the following default values:

# of Simultaneous Users = 120 (1560 subscribers)
Distance between CO and IAP/ISP = 5 miles
Distance between IAP and ISP = 20 miles
Line Leasing Period = 40 months
Compression Ratio = 2.67
T1 - T3 Threshold = 4

NUMBER OF INCOMING LINES (SIMULTANEOUS USERS)

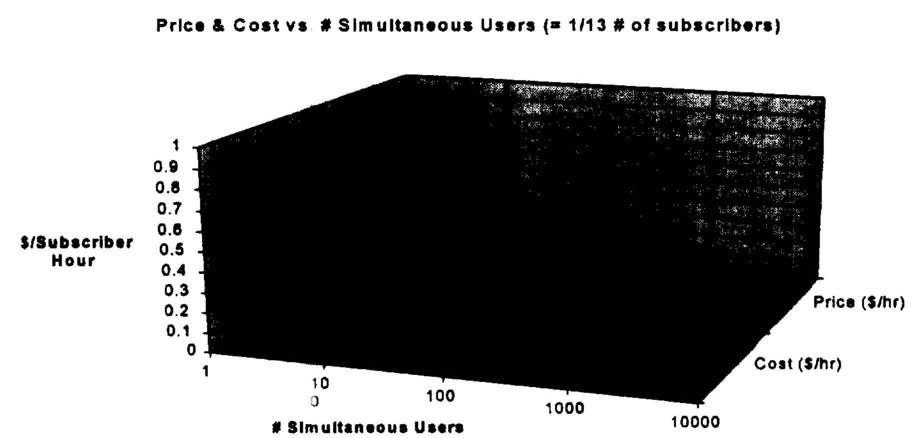

Figure C2: Price and Cost vx. Number of Simultaneous Users

What is most evident from the above graph is the presence of economies of scale. The greater the number of subscribers the greater the savings. This savings is maximized at approximately 1000 simultaneous users (13000 subscribers). The trend indicated here is largely due to the fact that larger capacity lines necessary for serving many subscribers are more cost effective than the smaller lines, i.e. a T3 line provides nearly 30 times the bandwidth of a T1 line, but the cost of a T3 line is only on the order of 5 times that of a T1 line. The relationship between cost and price demonstrated here is not significant because it was assumed that they both scaled equally in the model. In reality, rates would reflect the additional capacity regardless of cost.

DISTANCE FROM CO TO IAP/ISP

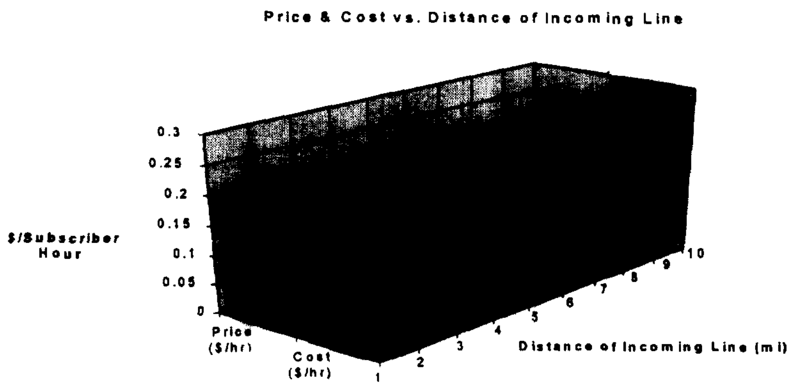

Figure C3: Price and Cost vs. Distance of Incoming Line

Here, it becomes evident that universal access issues are coming into play. Although the cost is highly dependent on the distance between the CO and the IAP, the rates (prices) are relatively independent of this distance. It follows from logic that rates are set up in this manner to allow anyone to have access regardless of their location. It is interesting to note that the price is "set" above the cost for the majority of cases encountered (as most people live within 8 miles of their CO). The trend seen here is related to the issue of a subsidy, but beyond stating this little can be concluded.

DISTANCE FROM IAP TO ISP

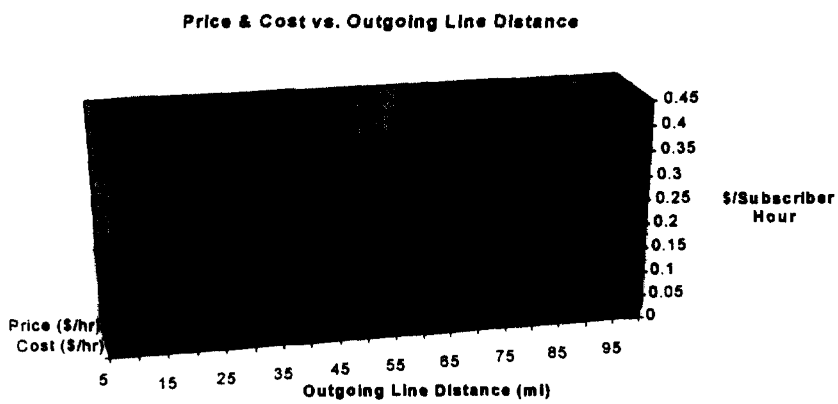

Figure C4: Price and Cost vs. Outgoing Line Distance

Unlike the analysis above this sensitivity analysis shows that the rate is highly dependent on the distance between the IAP and the ISP, but the cost is relatively independent (this actually relates the distance from the IAP's CO to the ISP's CO). Again, this addresses the issue of universal access. Businesses are often charged much higher rates than the actual associated costs. The reason costs are independent of this distance is because conduits and lines already exist between the COs and very little needs to be done to implement these lines. Where as lines from the CO to the place to business usually do not already exist.

LINE LEASING PERIOD

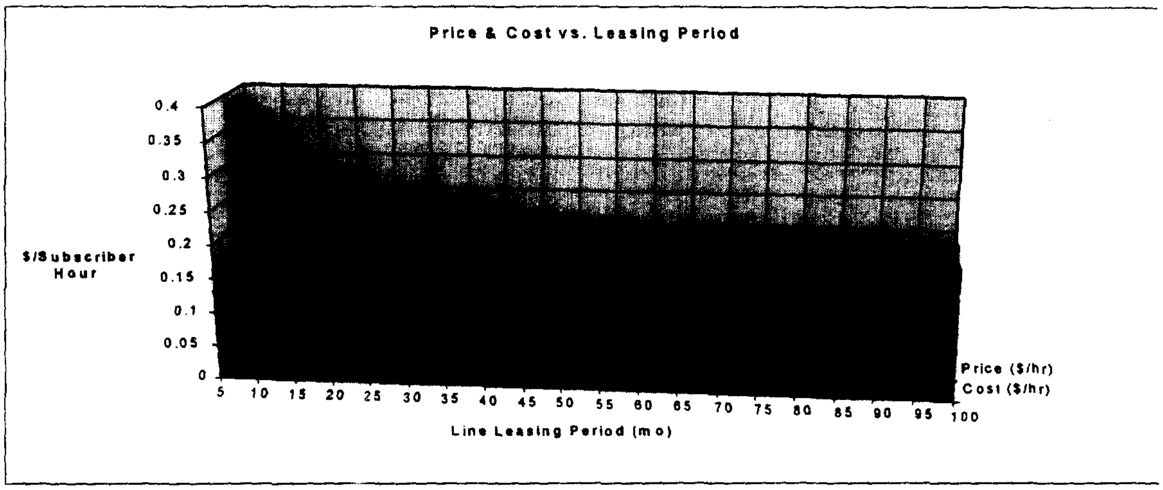

Figure C5: Price and Cost vs. Leasing Period

Varying the leasing period demonstrates the rate (price) savings offered by the Local Exchange Carrier (LEC). The LECs would prefer to lock their businesses into longer leases to assure stability and as such they provide incentives to lease for longer periods of time. At 36 and 60 months steps exist which relates a rate change. The savings apparent before 36 months, on a month to month basis, represents the spreading out of non-reassuring costs (NRC). As there are little real cost savings associated with leasing periods, the cost remains constant.

COMPRESSION RATIO

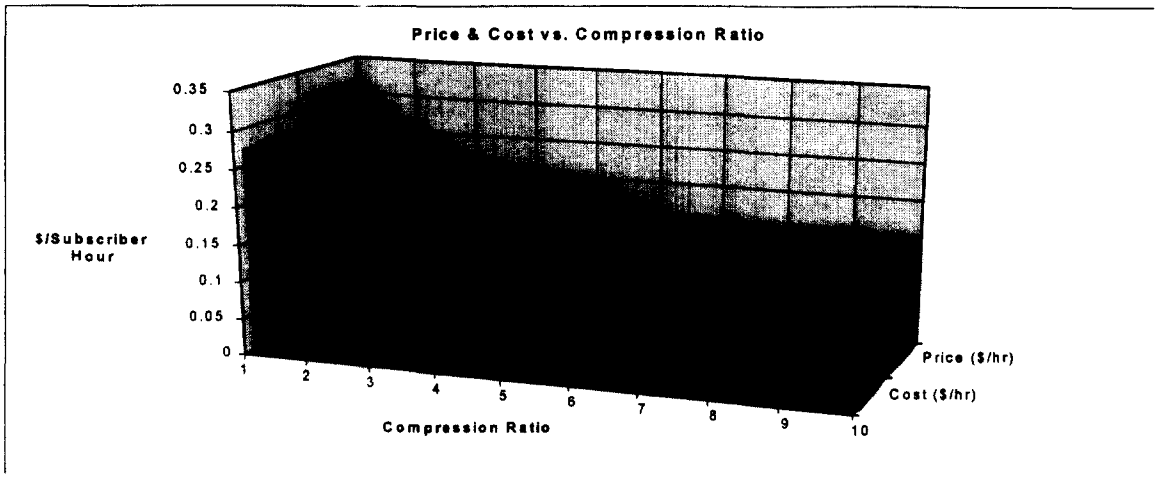

Figure C6: Price and Cost vs. Compression Ratio

The price and cost savings associated with the compression ratio at the IAP only applies to the outgoing lines (the above shows outgoing plus incoming, but the incoming portion is constant). The savings exist in a series of steps which come about because the number of outgoing lines decreases in integer steps, due to the assumption that only whole lines can be leased. The greater the compression the fewer the lines and thus the costs and the prices equally decrease.

T1 - T3 THRESHOLD

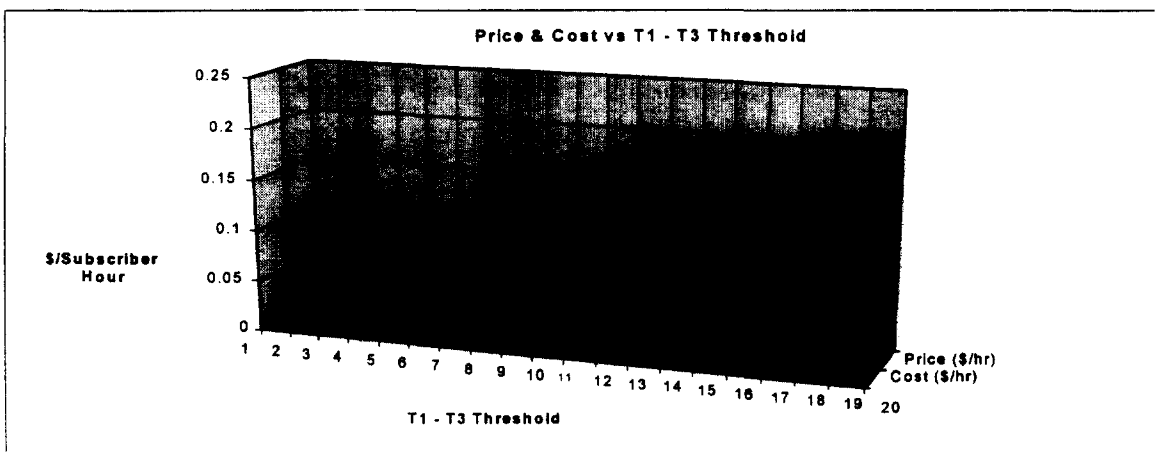

Figure C7: Price and Cost vs. T1-T3 Threshold

Since the T1 - T3 threshold is merely an assumed price change between a T1 and a T3 line this analysis relates very little. What it does show is that an LEC has leeway in changing the rates of the T3 lines in order to capture profit and reduce the benefit of the economies of scale demonstrated in the first graph. This should be considered important in the sense that there is a discrepancy between T1 - T3 cost differences and bandwidth differences

Appendix D: Gateway Cost Model

DESCRIPTION

a. The Architecture of a Gateway

In order to assess the cost of an Internet telephony (IT) gateway provider, it seems reasonable to begin by analyzing the cost structure of existing Internet access providers (IAPs). Once this is done, the business model of the "traditional" Internet service provider (WWW, email, etc.) can be modified to provide IT by incorporating the additional hardware and bandwidth requirements. Other economic variables such as marketing expenses, operating cost, and network architecture that account for the biggest chunk in long-term marginal cost of an IAP can be assumed to be very similar for an IT gateway provider.

Therefore, to get a realistic picture of an IT gateway provider's cost structure, it seems reasonable to use available balance sheet data[1] for IAPs, such as Netcom or PSInet, and accounting for the aforementioned IT specific changes in hardware and bandwidth utilization.[2]

However, we are not going to pursue this 'microscopic' approach since many of the ongoing cost when operating an IPOP are easier to include by using the aggregated items in the income statement of a 'typical' IAP.

b. Input Variables

The costs for incoming and outgoing trunk lines depend on the cumulative bandwidth requirements (T1/T3) and the distance from the central office. In the nominal

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[1] Cohen, J.H., Pankopf, T.L. *The Internet and the Online Services Segment: Content, Access and Equity Valuations*. Smith Barney; New York. Apr. 6, 1996. pp.10-14, 20-23.

[2] The equity of a typical IAP (such as Netcom or PSInet) comprises a certain number of IPOPs (210 for Netcom; 300 for PSInet), and possibly a few hubs that bundle and route the network traffic coming from the IPOPs. As an example, the cost of one of Netcom's IPOP are capitalized as follows:

> About $75,000 for installation and labor;
> U.S. Robotics Modem Rack: $66,000;
> two $6,000 Livingston port masters;
> Cisco 2501 router: $4,000;
> Cisco 7000 router located at a hub site: $100,000 (shared between approximately 30 IPOPs).

This totals to about $160,000 average up-front investment cost per additional IPOP. See Cohen and Pankopf, Dec. 11, 1995.

case, we assumed 3 miles distance from the central office that delivers the incoming lines. The distance between the IAP and the ISP (that provides the connection to a network access point (NAP) and thus to the Internet) is set to 20 miles in the nominal case. The costs associated with these parameter configurations have been discussed in the context of the local loop (see Appendix C). It is clear that in urban areas these local and upstream connection cost are considerably lower due to the concentration of COs and ISPs.

In some instances, IT providers may take advantage of the economies of scale offered by T3 line, which provide roughly 30 times the capacity of their T1 counterpart. These cases occur when the number of T1 lines exceeds the threshold value (T1-T3 Threshold); we have set this value to 6 T1 lines.

A straight-line depreciation over 50 months is assumed to account for up-front investments in the long-term marginal costs. The average monthly usage time on the Internet comes from typical IAP statistics (see c.). It is clear that an increased usage of Internet telephony is likely to push the average Internet usage time up. However, assuming stiff competition in the access provision business, prices will be kept near marginal cost. An increased usage pattern would therefore scale prices accordingly across the board of IT providers.

c. Statistics for a complete IAP

The size of an IAP can be measured in terms of the number of points of presence (IPOPs) and in terms of the total number of subscribers. As indicated before, we are going to limit our analysis to individual subscribers since the terms for business customers would vary significantly and complicate a unified treatment.

Cost for incoming and outgoing lines are essentially incurred per IPOP; therefore, in the cost model, we normalized the statistics of the complete IAP by the number of IPOPs. An important design parameter when dimensioning a network for a given subscriber base is the *ratio of IAP subscribers per incoming line.* The total number of incoming lines thereby equals the number of users that can be served simultaneously by the network (typically during peak hours). One possible way to estimate this parameter is to divide the number of typical usage hours in a month (prime time) by the average monthly usage time per subscriber (6.9 hours currently for AOL customers[3]). (Indeed, many ISPs, such as Netcom, provide free Internet access for their customers during non-prime-time hours.)

It is clear however that Internet telephony would induce a different usage pattern for Internet access. Assuming that average monthly Internet usage would increase to about 20 hours with Internet telephony, and given 64 hours per week that are effectively used for Internet access (8 hours on Monday through Friday, and 12 hours on Saturday

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[3]Cohen, J.H., Pankopf, T.L. *The Internet and the Online Services Segment: Content, Access and Equity Valuations.* Smith Barney; New York. Dec. 11, 1995. pp.21.

and Sunday), the nominal ratio of IAP subscribers per line would be around 14 (i.e., 64*(365/7/12)/20 = 14).

The profit margins for the IAP are assumed to be quite low at present (in fact, both Netcom and PSINet incurred operating losses during 1995 by offering extremely competitive prices for Internet access in an attempt to increase their subscriber base (penetration pricing)).

The pricing models for Internet access vary largely across the different IAPs. Typically, a 28.8 kbps dialup connection is priced at $15 to $30 per month[4]. It is clear that each IAP tries to maximize their revenues by exploiting consumers' preferences and their average usage time. Providing 'unlimited access' means in this context (in a competitive setting) just to price the expected average usage time according to long-term marginal cost.

d. Additional Hardware Cost

The only difference between the hardware involved in a classical IPOP and the future Gateway IPOP is the ability to directly handle phone calls. Therefore, a computer telephony board must be added to handle all the telephone signaling and to perform Touch-Tone and audio/voice signal processing tasks. In our model, we used the commercially available Dialogic D/240SC board, that can handle one incoming T1 line. This board performs some signal compression, from 64 kbps to 24 kpbs. In the likely case where more compression would be required, compression would be performed by an additional DSP board. Finally, to host all these boards, we assumed that a additional PC platform was necessary. We used the Dialogic Telco Platform that can host up to six Dialogic telephony cards.

e. Total cost of gateway

The total cost of the gateway is the sum of the internal cost, obtained from the analysis of a currently existing IPOP, and possibly the additional hardware cost for gateway implementation. In the cost model of a computer to computer connection, the additional hardware is not required. For the provision of phone to phone service, the additional gateway hardware does not account for a large share of the internal costs.

PURPOSE

The purpose of the Gateway model is to ascertain what the internal cost of providing Internet telephony will be. The determination of this cost gives a better understanding of the hardware, administrative, and overhead costs involved in providing Internet telephony.

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[4]See Cohen, J.H., Pankopf, T.L., and Juergens, J.L. "Internet Service Providers: Quarterly Directory". *Boardwatch Magazine*. Spring 1996.

ASSUMPTIONS

- The distance from the central office to the IAP is 3 miles, while the distance between the IAP and the ISP is 20 miles in the nominal case.
- The internal costs of an IT provider were assumed to be equal to the internal costs of a "traditional" IAP plus any additional Gateway hardware needed.
- To account for up-front investments in the long-term marginal costs, a straight-line depreciation over 50 months was assumed.
- Prices will be near marginal cost due to stiff competition in the Internet access provision business.
- Analysis is limited to individual subscribers to avoid the variety inherent in business customers service contracts.
- The ratio of IAP subscribers per incoming line is 14 subscribers per line in the nominal case.
- It was assumed that the number of personnel needed to operate an IT Gateway were equal to the number of personnel needed to operate an IPOP.

DISCUSSION OF RESULTS

From this model, the approximate cost of operating an IPOP for 1400 subscribers is $8,150 per month. This IPOP would be able to support 14 subscribers per line who utilize the service for 15 hours per week. If the IPOP were to offer an Internet telephony gateway, then the additional hardware cost would increase the internal costs to approximately $9,900 per month. This cost is equivalent to providing long distance service for $0.42 per hour.

SENSITIVITY ANALYSIS

When considering the primary output of the Gateway sub-model, namely the cost of providing Internet telephony service, the effects of the input variables on the ultimate solution must be determined. These costs are determined through the input of the number of subscribers per line the IPOP will serve, the IPOP's profit margin, the average usage time per subscriber of this service, the outgoing trunk utilization ratio, the average bandwidth each subscriber utilizes on the Internet, and the average size of the IPOP.

SUBSCRIBERS PER LINE

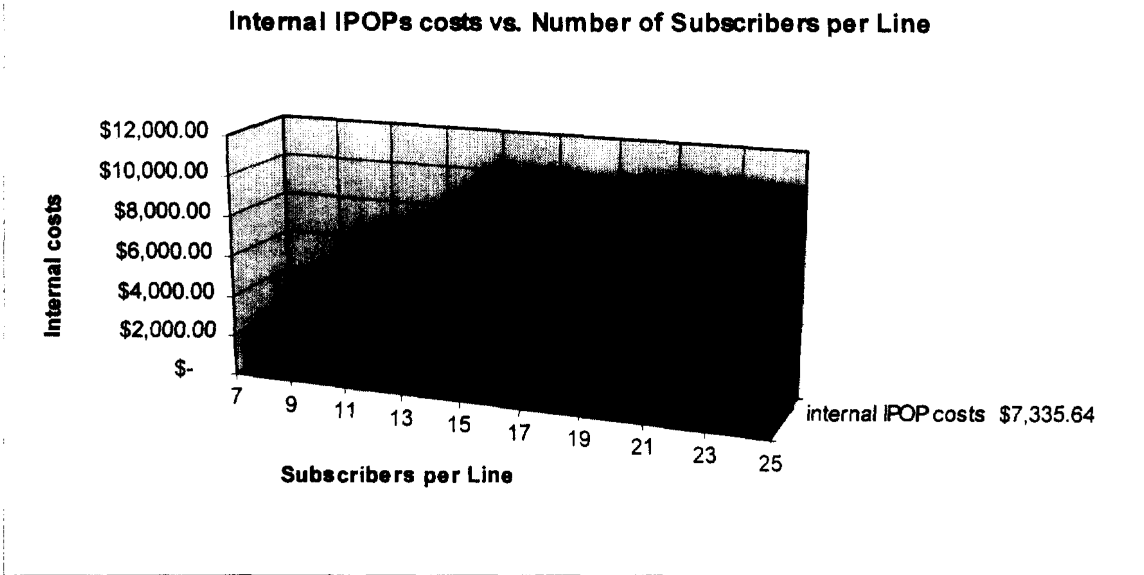

Figure D1: Internal IPOP costs vs. Number of Subscribers per Line

From our analysis, it appears that the number of subscribers per line has little effect on the internal cost to operate an IPOP. Once the costs of leasing incoming and outgoing lines are removed, the internal costs approach a constant value, regardless of how many subscribers there are per incoming line. However, our analysis is based on an existing IPOP, serving a fixed number of subscribers, and must be scaled up to the size of the Gateway under consideration. The size of the Gateway is defined by the number of simultaneous users, which also equals the number of incoming 64 kbps lines. Hence, the scaling factor, and the change in the internal costs of running the IPOP, have a 1:1 sensitivity to the number of subscribers per line assumed for the IAP.

When considering the profit margin of the IPOP and the average monthly usage time per subscriber, increases in either or both of these variables will decrease the cost per hour of providing Internet telephony. In addition, the assumptions made concerning the average profit margin for current providers of Internet access (0%) comes from the financial data published by the IAP studied. Considering that the average number of hours a subscriber actively uses his/her Internet access is 15 hours/month, this results in a cost per hour of approximately $0.70. The financial data announced by the IAPs that we studied should be reviewed by using the commonly agreed upon benchmark of approximately $0.50 per hour for providing Internet access.

The outgoing trunk utilization ratio proved to be quite insignificant to the final cost of providing service. This ratio did not change the number of outgoing lines until the ratio was 6% or below for our average subscriber bandwidth assumption of 1 kbps. As the average user increased in total bandwidth usage, this trunk utilization ratio began to become significant. Thus, as the consumer begins to need greater bandwidth access, the provider will need to consider the outgoing trunk utilization carefully when designing an IPOP.

NUMBER OF IPOPs

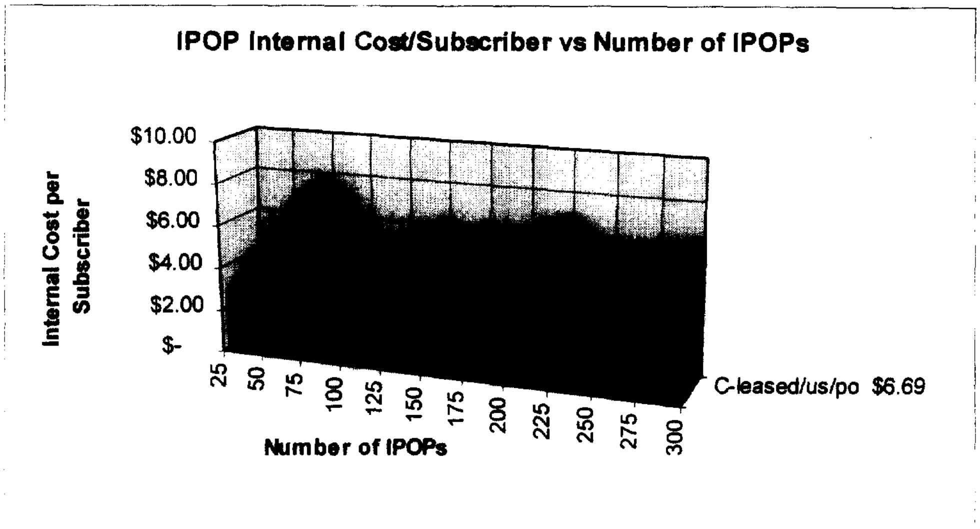

Figure D2: IPOP Internal Cost/Subscriber vs. Number of IPOPs

As the size of an IPOP increases to handle more subscribers, the administrative costs associated with that IPOP increases, in general, proportional to the number of subscribers per IPOP. However, the share of external costs (leasing lines and ISP) in the total cost of IPOP has some irregular points when the IPOP switches from T1 lines to T3 lines. When this switch occurs, the economies of scale associated with the T3 lines will cause the costs of providing Internet telephony to decrease. Irregularities in the internal costs also occur whenever the IPOP must purchase an additional platform for more telephony cards.

Appendix E: Upstream Cost Model

DESCRIPTION

This component consists of the upstream ISP, including the interconnection between the ISP and the NAP, as well as the Interconnection between the various NAPs. Cost of the upstream component as seen by the IAP/gateway is simply the price charged by upstream providers. The cost of the NAP connection is reflected in the price charged by the ISP.

PURPOSE

The purpose of this model is to determine what percentage of the total costs of Internet Telephony is due to upstream components. The model also provides an understanding of which variables strongly affect the upstream cost. The influence of specific variables is evaluated by a sensitivity analysis. The model is necessary to determine the cost incumbent upon the IAP due to upstream connections. These values will then be combined with the costs associated with the local loop and gateway to generate a total costs of providing Internet Telephony service. Lastly, the model provides a basic understanding of the upstream architecture necessary for Internet access.

ASSUMPTIONS

As discussed in the analysis of the local loop and gateway costs, the values employed in this model should be considered representative of real world costs. The relation between the variables and the costs provides for a qualitative understanding of the upstream architecture. In this section, we also introduce the key assumptions used to compute the total cost associated with the upstream connections.

List of Assumptions:

- The connection price paid to the upstream ISP by the IAP includes routing and ATM switching costs. The operating costs of the ISP are considered in the connection price.
- The interconnection bandwidth between the IAP and ISP is a set of incoming and outgoing T1 and/or T3 lines.
- The price that the IAPs pay the ISPs are calculated based on the number and type of the lines used as well as the utilization ratio of those lines. Figure E1 shows the cost to the IAP as a function of the Utilization Ratio.